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August 9, 2015

Dr. Robert Headrick
ONR Code: 332
Office of Naval Research
875 North Randolph Street
Arlington, VA 22203-1995

Dear Dr. Headrick,

Attached please find the progress report for ONR Contract N00014-14-C-0230 for the period of April 20, 2015 to July 19, 2015.

James C. Preisig
President, JPAnalytics LLC

CC: DCMA Boston
DTIC
Director, NRL

Report Documentation Page

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OMB No. 0704-0188

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6. AUTHOR(S)	5d. PROJECT NUMBER
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	5f. WORK UNIT NUMBER
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Progress Report #5

Coupled Research in Ocean Acoustics and Signal Processing for the Next Generation of Underwater Acoustic Communication Systems

Principal Investigator's Name:	Dr. James Preisig
Period Covered By Report:	4/20/2015 to 7/19/2015
Report Date:	8/9/2015
Contract Number:	N00014-14-C-0230
Firm Name and Address:	JPAnalytics LLC 638 Brick Kiln Road Falmouth, MA 02540 jpreisig@jpanalytics.com (508) 566-0236
Program Officer:	Dr. Robert Headrick ONR Code: 322 Office of Naval Research 875 North Randolph St. Arlington, VA 22203-1995 Robert.Headrick@navy.mil
Security Classification:	Unclassified
Distribution Statement:	Approved for public release. Distribution is unlimited.
Total Contract Amount:	$595,731
Costs Incurred This Period:	$48,261
Costs Incurred To Date:	$191,748
Estimated Costs To Complete:	$403,983

1. **Description:** Technical work this period has spanned four areas. The first was continuation of work on developing a methodology within the framework of asymptotic random matrix theory (RMT) to explicitly model the time variability of acoustic channels and using this to predict underwater acoustic communications systems performance. The background can be found in Progress Reports #3 and #4 for the prior two reporting periods. In this reporting period, a simplification of a particular cross-correlation matrix was developed which greatly simplifies the expressions. Work continues on both the full complexity and simplified expressions to determine if the simplified expression still accurately models the problem. This work falls under Research Task 1 from Section 2.2 of the Technical Approach and Justification.

   During this time period, the Principle Investigator also continued work on evaluating the correlation structure of received communications signals after they have been converted to the frequency domain via Fourier Transform as described in Progress Reports #3 and #4 for the prior two reporting periods. This work falls under Research Task 3 from Section 2.2 of the Technical Approach and Justification.

   During this time period, the Principle Investigator has also worked on both structured graphical based techniques and iterative Expectation Maximization (EM) based approaches to exploiting structure in the correlation of the received communications signals as described in Progress Report #4. This work is related to and exploits the results of the work described in the preceding paragraph. This work falls under Research Task 3 from Section 2.2 of the Technical Approach and Justification.

   During this time period, the Principle Investigator conducted one VHF acoustics test in a wave tank and prepared for and conducted one VHF ambient noise test in the ocean with Dr. Grant Deane at Scripps Institution of Oceanography. This was the first effort at making channel and noise characterization measurements in the field (tank and ocean). While some useful data was gathered, much of the effort in these two experiments revolved around diagnosing and addressing challenges of making VHF acoustic measurements in these environments. In parallel, the Principle Investigator continues to work with vendors to develop a new system for collecting fVHF acoustic field data that addresses a number of the short comings of the current system. This work falls under Research Task 2 from Section 2.2 of the Technical Approach and Justification.

   During this time period, the Principle Investigator also attended the Acoustic Society of America meeting in Pittsburgh, PA.

2. **Major Accomplishments this Period:** The work on asymptotic RMT for modeling the performance of underwater acoustic communications systems yielded a simplification based upon sample, lagged cross-correlations between Doppler coefficients at different frequencies which shows a relationship between this sample cross correlation and the ensemble correlation matrix of the received signal field. Specifically, if the sample cross correlation goes to zero as predicted by the Wide Sense Stationary portion of the WSSUS assumption, then the correlation matrix of the received signal field is time-invariant even though the environment (channel) and signal field themselves are time-varying.

3. **Results and Recommendations:** None

4. **Publications and Presentations:**

   M. Pajovic, J. Preisig, "Performance Analytics and Optimal Design of Multichannel Equalizers for Underwater Acoustic Communications", revised, resubmitted to and accepted for publication in the *IEEE Journal of Oceanic Engineering*.